Rapid Response Systems: The Stories

A Controlled Trial of a Rapid Response System in an Academic Medical Center

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Patients who need urgent transfer to the intensive care unit (ICU) and/or suffer a cardiopulmonary arrest frequently have changes in their clinical conditions and vital signs hours before these events.[1–3] These changes are often unrecognized or not clearly communicated early enough to quickly initiate interventions that might prevent or ameliorate further deterioration.[4]

Rapid response systems (RRSs) provide multidisciplinary clinical teams available 24 hours a day, 7 days a week, to provide immediate bedside care for deteriorating non–ICU patients.[5] Although there is growing evidence that clinically deteriorating patients may benefit from an RRS,[6–8] critics believe that additional large-scale randomized control trials are needed before RRSs become the standard of care.[9–11] Hiring additional personnel to staff RRS teams, especially dedicated team nurses, may add significant staffing costs for hospitals, and it is unclear which RRS model is most efficacious or cost-effective, especially in teaching hospitals.[12] Previous research has been unable to demonstrate if the improved outcomes found in some prior RRS trials were from better nursing recognition of patient deterioration and physician communication and notification (the activation limb)[13] or from the establishment of a formal team with a standardized response (the response limb).[14,15] It is also important to study the effects of different RRS models, especially models that have not previously received attention and may currently be common in practice.

We hypothesized that redesigning the response to clinically deteriorating non–ICU patients with a medical emergency team (MET)—versus nurse-led team models, rapid response teams (RRTs)[8]—using housestaff physicians as the first physician responders and existing nursing resources would improve patient outcomes while remaining cost-neutral. We hypothesized that a successful RRS would identify candidates for ICU transfer earlier in their deteriorating course, resulting in fewer overall ICU transfers while leading to earlier ICU transfer for those patients still needing ICU care. We also hypothesized that the patients who are transferred to the ICU will be more stable at the time of transfer. Finally, we expected to find a reduction in mortality rates associated with the RRS intervention.

Methods

The study was conducted on the adult medical service and included a six-month retrospective baseline period from May 2005 to November 2005, a one-month transition phase, and a prospective six-month intervention trial from December 2005 to June 2006. The study hospital's Institutional Human Subjects Review Board approved the study.

Study Site and Patient Population

The study hospital is a 745-bed tertiary care academic medical center (AMC) in New England. The study included six control (non–RRS) patient care units (90 beds) with predominantly cardiology, hematology, and oncology patients. The intervention (RRS) units included four general medical patient care units (60 beds). Patients with a do-not-resuscitate (DNR) code status were eligible for treatment by the MET, but patients with a comfort-measures-only (CMO) status were not candidates for use of the RRS. Patients were excluded if they transferred or died within four hours of arrival to the study units.

Patients with acute cardiac conditions needing transfer to a critical care unit were preferentially transferred to the coronary care unit (CCU). Hematology/oncology patients, including the bone marrow transplantations service (BMT), who needed transfer to an ICU, were preferentially sent to the BMT-ICU. General medicine and other medical subspecialty patients who needed ICU transfer were preferentially sent to the medical ICU (MICU). The ICUs and CCUs have dedicated attending intensivists, cardiologists, and fellows who are routinely in-house from 7:00 A.M. to 6:00 P.M.

After the beginning of the study, and previously unbeknownst to the study investigators, the MICU increased in bed capacity. The MICU bed capacity increased during the baseline period in two stages: from 10 to 16 beds and then to 20 beds. The MICU bed capacity throughout the intervention period

(20 beds) was 37% greater than the mean capacity during the baseline period (14.6 beds). The CCU and BMT-ICU did not change their 10-bed capacities. The increased MICU bed capacity predominantly affected the intervention units because the majority of their in-hospital critical care transfers continued to go to the MICU.

Outcomes of Interest and Definitions

Primary outcomes of interest included unplanned ICU transfers, ICU and overall same-admission mortality rates and lengths of stay (LOS). *Unplanned ICU transfers* were defined as urgent floor transfers to the ICU, excluding elective postoperative ICU care (planned transfers). *ICU LOS* was the total days in the ICU following direct transfers from a study unit into an ICU. Other ICU patient-days resulting from direct admission into the ICU from the emergency department, operating room, or nonstudy units were excluded from ICU LOS calculations. Multiple unplanned transfers to the ICU during an admission for a single patient were counted as independent transfers, but the ICU days were summed to determine the total ICU LOS per admission. Patients with multiple transfers to the floors during the same admission were also summed for the total *study unit LOS*. Patients whose admission included transfers between RRS units and non–RRS units were excluded from analysis.

Secondary outcomes included cardiac arrests, unexpected deaths, ICU and pre–ICU Acute Physiology and Chronic Health Evaluation II (APACHE II) scores, and time to transfer to the ICU. *Unexpected deaths* were deaths in patients who did not have a preexisting DNR order. We sought to determine if the RRS intervention led to earlier ICU transfer for clinically deteriorating patients and to better (lower) severity of illness scores on arrival to the ICU. The APACHE II score was measured at two points in time. The *Pre–ICU APACHE II score* was used to determine the severity of illness when the decision was made to transfer the patient to the ICU and included the eight-hour period prior to physical transfer. The APACHE II score has previously been used in other studies to determine the severity of patient illness prior to ICU transfer.[16] The *ICU APACHE II score* was measured 24 hours after transfer into the ICU and less if the patient died or transferred out of the ICU before 24 hours.

Time to ICU transfer was used to determine the efficiency of transferring a clinically deteriorating patient from the floor to the ICU and was calculated from the first documented positive early warning criterion/criteria (EWC) within the eight-hour time frame before ICU transfer until time of physical arrival in the ICU, as documented in the ICU nursing notes. Although we could capture the computerized ICU transfer order entry time, the order entry time did not always correlate with the time the clinical decision was made for ICU transfers. Transfer orders were usually entered by the ICU receiving team after the patients' arrival in the ICU. Delays in actual transfer between the time of the decision to transfer and arrival in the ICU could result from factors outside the RRS or study floor processes of care. Examples of external factors causing delayed ICU transfer include unavailable ICU beds or delays in obtaining an emergent imaging study in the radiology department prior to ICU arrival. Patient demographic data collected included age, gender, Charlson comorbidity score, admission source, admission service, and the primary admitting diagnosis.

Study Design and Data Collection

The MET members included the patient's assigned or on-call covering intern and resident physicians, a respiratory therapist, and a float-pool critical care nurse. The critical care nurse had other responsibilities throughout the hospital, which at times could slow his or her response to an RRS event. In November 2005, the RRS was introduced to the participating intervention unit nurses, respiratory therapists, medical housestaff, and attending hospitalist physicians with educational meetings and e-mail communications. Housestaff training was limited to a one-hour didactic session just before the intervention and a follow-up meeting several weeks later to review opportunities for improvement. Similar training sessions and follow-up meetings were provided for the nursing staff on the intervention unit. The critical care nurses and respiratory therapists who staffed the MET did not receive additional training.

The RRS consisted of the following three process changes:

1. A set of EWC used to initiate the RRS
2. Standardized communication of urgent patient information by nurses to physicians using the Situation-Background-Assessment-Recommendation (SBAR) tool[17]
3. Standardized physician responses and a patient care escalation algorithm

The EWC included specific numerical thresholds, as well as descriptive criteria of pattern recognition of unstable patients sufficient to worry the bedside nurse (Table 1, page 419). Positive EWC that met or exceeded the criteria were used to trigger an RRS event. Our EWC were approved by both the nursing and medical leadership and were based on institutional modifications of EWC used in previous RRS studies. Nurses were given training in how to use the SBAR tool to concisely inform physicians about the patient's status.

The patient care escalation algorithm included several steps.

Table 1. Early Warning Criteria to Initiate the Rapid Response System

Category	Early Warning Criteria
Respiratory	Respiratory rate < 8 breaths per minute
	Respiratory rate > 35 breaths per minute
	Acute change in oxygenation saturation to < 85% for > 5 minutes
	Need to increase supplemental O_2 to 100% or starting non-rebreathing O_2 mask
	New onset of severe dyspnea or threatened airway
Cardiovascular	Heart rate < 40 beats per minute
	Heart rate > 140 beats per minute with symptoms
	Heart rate > 160 beats per minute with or without symptoms
	Systolic blood pressure < 85 mm Hg
	Systolic blood pressure > 200 mm Hg for > 30 minutes
	Diastolic blood pressure > 110 mm Hg with symptoms
Neurologic	Acute mental status change: unconsciousness, lethargy, severe agitation or delirium
	Sudden fall in Glasgow Coma Scale ≥ 2 points
	New focal weakness
	Prolonged or repeated seizures
Other	New decrease in urine output to < 50 cc over 4-hour period
	Uncontrolled bleeding
	Color change of patient or extremity: pale, dusky, or blue
	Temperature > 105° F (40.5° C)
	Staff member worried and does not satisfy any of the other criteria

First, the paged covering intern was expected to see the patient within 5 minutes and notify the covering resident who, if available, immediately assisted the intern. Second, if the patient's EWC abnormality or overall condition did not improve within 30 minutes, and if not done already, the intern was expected to notify the attending physician (for patients with transient reversible events, such as quickly resolved severe bronchospasm, attending notification was not required). Third, if the patient remained in distress for an additional 30 minutes, and if not already done, the intern was expected to contact the intensivist or cardiologist on call to review the case and/or discuss possible ICU transfer. An RRS event form was used to record the EWC, the nursing communications, response times, the physician assessment and plan, patient disposition and, if applicable, time of the attending physician notification.

The hospital billing database was used to identify admissions and transfers to the study units and the ICUs during the retrospective baseline period. During the prospective intervention period, an automated daily notification tool was developed for the research staff to identify study unit admissions and ICU transfers. A research assistant identified RRS events using the daily paging operator logs and completed RRS event forms. During chart abstractions of physiologic data for calculating pre–ICU APACHE II scores for ICU transfer, study staff were not blinded as to which patients did or did not have an RRS intervention.

Statistical Analysis

Most continuous-outcome variables analyzed were found to be approximately normally distributed. For those outcomes not normally distributed, appropriate transformations (for example, log) were applied. However, the results changed very little when we used the transformed or untransformed variables, so for the purposes of interpretability, we used the untransformed variables. The multinomial distribution was used for categorical outcomes, and the Poisson distribution was used for analyzing rates. For any of these outcomes, when calculating the *p* values for comparisons of pre versus post within a treatment or pre minus post across treatments, generalized estimating equation test statistics were used to account for within-patient clus-

Table 2. Demographics*

Study Units	Non–Rapid Response System Units			Rapid Response System Units			All Units
Study Period	**Baseline (pre)**	**Control (post)**	***p* Value**	**Baseline (pre)**	**Intervention (post)**	***p* Value**	***p* Value**
Patients *n*	2284	2240		2427	2568		
Age mean years (S.D.)	60.5 (16.1)	60.2 (16.1)	.52	61.4 (18.3)	60.3 (18.3)	.03†	.23
Female *n* (%)	1,031 (45.1)	997 (44.5)	.65	1,337 (55.1)	1,495 (58.2)	.02†	.04†
Charlson score mean (S.D.)	2.41 (2.93)	2.47 (2.98)	.46	1.95 (2.38)	2.12 (2.59)	.007	.26
Admissions n	2738	2662		2738	2909		
Admission source *n* (%)			.20			.89	.30
Emergency department	1,132 (41.3)	1,055 (39.6)		1,866 (68.2)	2,000 (68.8)		
Elective admission	735 (26.8)	696 (26.1)		235 (8.6)	257 (8.8)		
Transfer from another hospital	583 (21.3)	633 (23.8)		394 (14.4)	404 (13.9)		
Other	288 (10.5)	278 (10.4)		243 (8.9)	248 (8.5)		
Service (while on study unit) *n* (%)			.003†			.19	.02†
General medicine	236 (8.6)	291 (10.9)		1,735 (63.4)	1,907 (65.6)		
Cardiology	1,061 (38.8)	1,014 (38.1)		121 (4.4)	106 (3.6)		
Hematology-Oncology-BMT	1,182 (43.2)	1,137 (42.7)		255 (9.3)	253 (8.7)		
Renal medicine	19 (0.7)	20 (0.7)		171 (6.2)	127 (4.3)		
Pulmonary medicine	24 (0.9)	34 (1.3)		73 (2.6)	124 (4.2)		
Surgery	159 (5.8)	109 (4.1)		74 (2.7)	94 (3.2)		
Other	57 (2.1)	57 (2.1)		309 (11.2)	298 (10.1)		

* S.D., standard deviation; BMT, bone marrow transplant.

† Statistically significant.

tering caused by repeated observations (for example, re-admissions) on the same units in the baseline and intervention study periods.[18]

Results

Patient Characteristics

We studied 4,524 patients with 5,400 admissions to the non–RRS units and 4,995 patients with 5,647 admissions to the RRS units. During the intervention phase, patients on the RRS units were more likely to be female, younger, and sicker (Table 2, above). The admitting diagnoses reflect the different services across the units, and these diagnoses were not significantly different between the baseline and intervention periods (Table 3, page 421). A total of 25 admissions (0.2%) were excluded from analysis because of transfer between RRS and non–RRS units.

Patient Outcomes

Mortality Rates. Mortality rates for patients on the RRS units during the intervention period were similar to those during the baseline period (2.4% versus 1.8%) as well as for the subset of patients transferred to the ICU (27.6% versus 21.2%). During the entire study, there were only 28 cardiac arrests (16 on the non–RRS units and 12 on the RRS units) and 6 unexpected deaths (4 on the non–RRS units and 2 on the RRS units) on the study units, and there were no statistically significant differences for these outcomes between the baseline and intervention phases. The remaining 325 deaths were either in patients with a DNR status or in the ICU. Adjusting for the difference in illness severity (Charlson scores) between the RRS and non–RRS units during the intervention phase did not affect the significance (*p* values) of our findings.

Length of Stay. The overall hospital LOS was not significantly different between the two study periods for control and intervention patients. The study unit LOS decreased slightly during the intervention period on the RRS units (3.46 versus 3.78 days; $p = .004$). The ICU LOS for the unplanned ICU transfers from all units was not significantly different in the intervention period compared with that of the control period.

Unplanned ICU Transfers and MET Use. During the inter-

Table 3. Admitting Diagnoses*

	Non–Rapid Response System Units *n* (%)		Rapid Response System Units *n* (%)	
Admitting Diagnosis	**Baseline (pre)**	**Control (post)**	**Baseline (pre)**	**Intervention (post)**
Acute coronary syndrome	446 (16.3)	430 (16.2)	192 (7.0)	144 (5.0)
Solid malignancy	444 (16.2)	403 (15.1)	119 (4.3)	133 (4.6)
Hematogenous malignancy	357 (13.0)	368 (13.8)	32 (1.2)	33 (1.1)
Other gastrointestinal	64 (2.3)	190 (7.1)	115 (4.2)	250 (8.6)
Chest pain	120 (4.4)	163 (6.1)	97 (3.5)	171 (5.9)
Heart failure	179 (6.5)	165 (6.2)	74 (2.7)	64 (2.2)
Dysrhythmia	183 (6.7)	177 (6.6)	57 (2.1)	50 (1.7)
Pneumonia	38 (1.4)	49 (1.8)	150 (5.5)	167 (5.7)
Syncope	77 (2.8)	66 (2.5)	126 (4.6)	126 (4.3)
Fever	75 (2.7)	68 (2.6)	79 (2.9)	89 (3.1)
Gastrointestinal bleed	12 (0.4)	23 (0.9)	114 (4.2)	111 (3.8)
Obstructive lung disease	10 (0.4)	18 (0.7)	95 (3.5)	110 (3.8)
Renal failure	21 (0.8)	26 (1.0)	99 (3.6)	75 (2.6)
Anemia	42 (1.5)	59 (2.2)	56 (2.0)	49 (1.7)
Cellulitis	14 (0.5)	12 (0.5)	95 (3.5)	79 (2.7)
PE/DVT	35 (1.3)	34 (1.3)	61 (2.2)	58 (2.0)
Dehydration	32 (1.2)	34 (1.3)	36 (1.3)	57 (2.0)
Acute pancreatitis	4 (0.1)	2 (0.1)	72 (2.6)	74 (2.5)
Urinary tract infection	7 (0.3)	12 (0.5)	54 (2.0)	50 (1.7)
Septicemia	17 (0.6)	12 (0.5)	40 (1.5)	31 (1.1)
Stroke	19 (0.7)	11 (0.4)	39 (1.4)	28 (1.0)
Other	542 (19.8)	340 (12.8)	936 (34.2)	960 (33.0)
Total	2,738	2,662	2,738	2,909

* PE, Pulmonary embolus; DVT, deep vein thrombosis.

vention period, the proportion of patients transferred to the ICU increased on the RRS units (3.1% versus 2.0%; $p = .007$). During the six-month intervention trial, 109 patients, or 4.2% of patients on the RRS units, had at least 1 RRS event, including 78% (85/109) who survived to discharge. There were 131 RRS events, resulting in a mean of 1.2 events per patient, and 37% (49/131) of events resulted in transfer to an ICU.

All patients with an RRS event had at least one positive EWC. Among patients with an RRS event, 57 (44%) had a single positive EWC, 49 (37%) had two positive EWC, and 25 (19%) had three or more. The most common EWC used to initiate the RRS were an acute change in mental status (40%), systolic blood pressure < 85 mmHg (31%), oxygen saturation < 85% (23%), and respiratory rate > 35 breaths per minute (19%). The most common actions by the MET were fluid resuscitation (53%), obtaining an emergency bedside echocardiogram (50%), obtaining an emergency imaging study (50%), providing nebulized bronchodilator treatments (18%), transfusion of blood products (15%), and applying noninvasive positive airway pressure support (13%).

Process Outcomes

APACHE II Scores. The ICU APACHE II scores for unplanned ICU transfers did not change for patients transferred from the RRS units during the intervention period as compared with the non–RRS units (23.1 versus 22.3). Similarly, the pre–ICU APACHE II scores were unchanged for these groups (19.3 versus 19.0). The mean times to ICU transfer for the control non–RRS units during the baseline and intervention periods were 223 minutes (standard deviation [S.D.], 193 minutes) and 208 minutes (S.D., 196 minutes; not significant), respectively. The mean time to ICU transfer for

Table 4. Patient Outcomes*

Study Units	Non–Rapid Response System Units			Rapid Response System Units			All Units
Study Period	Baseline (pre)	Control (post)	*p* Value	Baseline (pre)	Intervention (post)	*p* Value	*p* Value
Discharge disposition			.69			.23	.65
Discharged alive *n* (%)	2,636 (96.3)	2,553 (95.9)		2,689 (98.2)	2,838 (97.6)		
Discharge home *n* (%)	2,250 (82.2)	2,192 (82.3)		2,117 (77.3)	2,247 (77.2)		
Discharge to a facility *n* (%)	386 (14.1)	361 (13.6)		572 (20.9)	591 (20.3)		
Died	102 (3.7)	109 (4.1)		49 (1.8)	71 (2.4)		
Hospital LOS mean days (S.D.)	6.65 (9.2)	6.95 (8.7)	.24	5.14 (6.4)	5.03 (5.9)	.51	.17
Cardiac arrests on study unit *n*; rate†	9; 3.4	7; 2.7	.66	4; 1.5	8; 2.8	.17	.17
Discharged alive *n* (%)	2 (22.0)	2 (29.0)		2 (50.0)	4 (50.0)		
Study unit LOS mean days (S.D.)	4.85 (6.3)	4.92 (6.4)	.66	3.78 (4.4)	3.46 (3.8)	.004‡	.06‡
Patients with unplanned ICU transfers *n*	68	89		52	87		
Discharged alive *n* (%)	42 (61.8)	57 (64.0)	.77	41 (78.8)	63 (72.4)	.41	.40
Unplanned ICU Transfer *n*; rate†	71; 25.9	93; 34.9	.06	55; 20.1	91; 31.2	.007‡	.49
Pre–ICU APACHE II Score mean (S.D.)	20.9 (5.4)	20.0 (5.6)	.31	19.0 (6.4)	19.3 (7.4)	.81	.42
ICU APACHE II Score mean (S.D.)	24.2 (8.1)	23.4 (8.1)	.55	22.3 (7.2)	23.1 (8.0)	.56	.41
ICU LOS mean days (S.D.)	5.97 (6.4)	6.79 (8.0)	.50	6.78 (8.1)	5.60 (6.8)	.42	.31

* LOS, length of stay; S.D., standard deviation; ICU, intensive care unit; APACHE II, Acute Physiology and Chronic Health Evaluation; Pre–ICU APACHE II score = APACHE II score for the 8-hour period leading up to transfer to the ICU; ICU APACHE II score = APACHE II score for the initial 24 hours after transfer into the ICU.

† Rate per 1,000 admissions.

‡ Statistically significant.

RRS–unit patients during the baseline period was 249 minutes (S.D., 180 minutes). The mean time to ICU transfer for RRS–unit patients during the intervention period who did and did not have an RRS event were 195 minutes (S.D., 161 minutes) and 142 minutes (S.D., 180 minutes; $p = .02$), respectively.

Discussion

We successfully implemented an RRS on the general medical floor of an AMC without an incremental increase in personnel resources. Although the RRS was enthusiastically accepted by the staff, we were unable to demonstrate that the RRS improved clinical or process outcomes.

Our study is one of the few controlled trials that have evaluated an RRS. Winters and colleagues recently conducted a systematic review of the RRS literature and found only eight studies that met inclusion criteria.[19] One of the strengths of our study was the use of both pre-intervention and concurrent control groups. However, we could not control for admitting diagnoses because the study hospital did not have sufficient general medical units to serve as control units. We recognize that conducting a randomized trial of a new systems response to manage patient crises that was limited to only some of the hospital's patient care units presented greater challenges for success. On the other hand, randomizing the RRS intervention at the patient level would have presented far greater concerns, including the potential for introducing harmful consequences, such as delays in the management of patients in respiratory distress or shock. Randomization of patients to control and intervention groups on the same patient care floor would likely have produced significant confusion among bedside nurses, who must act quickly when patients are clinically deteriorating, and might have resulted in delays for patients needing urgent care.

A number of possible reasons may account for our inability to find benefit. A recent Cochrane review on RRS suggests that two methodologic characteristics that our study had might have contributed.[11] First, our study had a brief time frame of one month from RRS implementation to evaluation—perhaps insufficient time for the intervention unit to successively make the transition to the large set of process changes. Second, the level of training for our MET members was less intensive than has been reported in studies with improved outcomes.[7] Third, we did not include strict enforcement policies for RRS use.

Although we made a concerted effort to learn and respond as to why the RRS was not used for missed opportunity cases, we did not enforce universal use of the RRS by the intervention staff nurses. Some of the reasons staff gave for not calling the RRS in our study were similar to those described in the multihospital Australian randomized controlled trial conducted by Hillman and colleagues.[14] The most common reasons for not initiating the RRS and, in part, explaining underuse of our RRS, included poor recognition of the clinically deteriorating patient with positive EWC, lack of awareness of the RRS, and reluctance to call the MET. These factors illustrate the importance of institutionalizing culture changes towards the care of failing patients. Buist and colleagues have suggested that the acceptance of the RRS concepts is as important as the team's actions.[20]

Our MET included the same medical housestaff who also cared for patients on the control units, which could have reduced incremental improvements in the RRS intervention group. However, unlike the Hillman study,[14] we did not demonstrate an overall temporal improvement in outcomes for both control and intervention units. The success seen in previous RRS intervention studies in nonteaching hospitals may in part have resulted from improved physician bedside responses to urgent situations. This effect may not carry over to teaching hospitals, where housestaff are available 24 hours a day, 7 days a week, and may routinely be available to respond more quickly to deteriorating patients. The effectiveness of an AMC–based RRS may also be enhanced by continual education, including specific training for common RRS emergencies. Sebat and colleagues have demonstrated reduced mortality for patients with shock when their RRS team more consistently and rapidly employed protocolized goal-directed therapy.[21]

Another possible reason for our inconclusive findings may have been the nursing and physician composition of our MET. One might suspect that the medical background and training of the RRS members (that is, attending or critical care physicians in other studies versus housestaff physicians in our study) could have an impact on outcomes. However, to date, there have been no controlled trials comparing the RRS members' expertise and patient outcomes. Except during cross-coverage periods, our model had the theoretical advantage of including first-responder physicians who knew the patients. Unlike a cardiac arrest response, which follows strict protocols and has limited clinical scenarios, RRS event responders with previous patient knowledge may have an advantage. On the other hand, if a patient's condition has deteriorated, bringing in a fresh caregiver whose judgment may not be locked into the conceptual framework used by the original team might be advantageous.[22]

There are effective RRS models that employ "consultant" physicians to provide expertise during RRS events. The role of the primary care team during those events is less clear. Participation of the primary care housestaff team is an important concern for residency training programs who have the responsibility of educating housestaff to manage such events.[23] The leadership and expertise provided by a critical care attending and/or fellow during an RRS event could be a valuable addition to a successful AMC RRS program. Critical care medicine–led RRS programs in AMCs in Pittsburgh and Australia have resulted in fewer cardiac arrests.[7,24] Regarding the nursing member of the RRS, we used the critical care nursing float pool, rather than a new full-time RRS nurse, to staff our RRS. The float-pool nurses had many other responsibilities and may have been unable to attend throughout all RRS events.

We introduced a new escalation care algorithm to provide a structured mechanism for the first responders to move up the chain of command for attending and consultant inclusion. Our reviews of RRS event forms and subsequent discussions with RRS participants indicated that the algorithm was used inconsistently. Again, we did not include a compliance enforcement policy during the study. Although attending physicians were usually notified that their patients had an RRS event when the patient's condition failed to quickly improve, the critical care and cardiology attendings were usually notified late (not until the patient needed ICU transfer) or not at all.

One of our prestudy hypotheses of the effects of an RRS—improved ICU use with overall reductions in unplanned ICU transfers—may have been confounded by the expansion in the MICU bed capacity. The MICU bed capacity started to increase during the baseline period and resulted in a 37% greater mean bed capacity for the intervention period as compared with the baseline period. Increased ICU capacity has been found to increase ICU use, although usually with patients from other sources (for example, the emergency department, interhospital transfers, and other ICUs).[25] It is noteworthy that our baseline rates of unplanned ICU transfer (25.9–34.9 per 1,000 admissions) are far higher than reported in frequently cited Australian RRS studies (2.3[26]–5.29[14] per 1,000 admissions). Our higher rates of unplanned ICU transfer may reflect a sicker population of non–ICU patients or increased ICU use rates.

Delayed or suboptimal intervention for inpatients with unexpected clinical deterioration represents a common clinical problem that is associated with increased morbidity and mortality compared with those who receive timely, appropriate

intervention. A British study found that over half of patients transferred to the ICU were considered to have received substandard care, including 39% of patients with delays in transfer.[4] In a study examining the effects of delayed transfer of inpatients to the ICU, patients classified as "slow transfers" were almost four times more likely to die in-hospital as compared with other transferred patients.[16] We found a secular trend to decreased time to transfer to the ICU between the baseline and intervention periods, which was likely due to the overall increase in ICU beds for medical patients. The increased MICU capacity may have also alleviated the previous heavy occupancies of overflow MICU patients in the other ICUs. We expected that the RRS intervention would improve the times to ICU transfer, but the intervention resulted in a delay in ICU transfer. One possible explanation was that the MET performed diagnostic and therapeutic interventions on the floor which were previously done in the ICU, resulting in delayed ICU transfer.

The study has a number of additional limitations. It was done only in medical patients in a single AMC. Our findings may not be generalizable to RRSs for surgical, pediatric, or other services or in nonteaching hospitals. As described earlier, patient demographics between the control and intervention units were dissimilar and may have contributed to our findings. We assessed the time to ICU transfer and severity of illness at time of ICU transfer but did not control for the impact of the unexpected doubling of the MICU bed capacity on outcomes or decision making for whom to transfer (for example, less-sick patients) and when to transfer them to the ICU (for example, before a patient decompensates further). An additional limitation is that our study did not have sufficient power to determine an effect of the RRS on cardiac arrests and/or unexpected deaths. As mentioned above, it was limited in geographic scope and was not a hospitalwide intervention. An intervention involving significant system and protocol changes must overcome many possible barriers and would be more difficult to carry out than an intervention in only a few units. Finally, we did not measure the impact of the RRS intervention program on the culture or knowledge base among the house-staff physicians treating acutely deteriorating patients.

Conclusion

We were unable to demonstrate that an RRS with medical house-staff and existing nursing resources improved clinical and process outcomes for medical patients. Having an outstanding medical housestaff already present 24 hours a day, 7 days a week may mitigate some of the RRS gains seen in nonteaching hospitals. However, the education of the team members, including ongoing training and support programs, may be a critical component to a more successful RRS program. The addition of dedicated RRS nurses may also contribute to the successes reported elsewhere, though the cost-benefit of hiring additional staff is still unclear. Future research needs to address which RRS model is most effective, in both teaching and nonteaching hospitals, and the value of providing additional RRS staffing resources. J

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